FIBER REINFORCED PLASTIC TUBULAR BODY AND METHOD OF PRODUCTION THEREOF

BACKGROUND OF THE INVENTION

Technical Field

[0001] This invention relates to a fiber reinforced plastic (hereinafter, for all purposes in this application, termed "FRP") tubular body, in particular to a long, large diameter or curved FRP tubular body, and to a method for the production thereof.

Background Art

[0002] Light weight, high-strength FRP materials are the subject of attention in various industrial fields, and CFRP (carbon fiber reinforced plastic) is a particular focus of attention on account of its outstanding mechanical properties and the like. Large tubular bodies made of metal are heavy, and their ease of handling is poor. Furthermore, there is a fear of rusting. When such metal tubular bodies are used, large-size heavy machinery is required, and the base foundations need to be made firm. Again, in the case of curved supports, deflection under their own weight is considerable, and there are limits to the length of tubular arms made of such tubular members. Moreover, since their impact absorption capacity is not all that high, in the case, for example, of the impact between a motor vehicle and such a support, there is considerable damage to the motor vehicle and risks to the vehicle occupants are considerable.

[0003] On the other hand, in the case of the molding of FRP tubular bodies, normally the filament winding method or methods using prepregs are employed, but these suffer from the following problems.

[0004] When FRP tubular bodies are fabricated by means of the filament winding method, normally a mandrel is fitted to a winding means and resin-impregnated reinforcing fiber is wound onto the mandrel, but in the fabrication of a long large-diameter FRP tubular body, for example a large size tubular body of an outer diameter of about 5 m and a length of about 10 m, by the filament winding method, in addition to various problems from the point of view of the operating environment, hygiene and safety, there are also limitations in terms of equipment because the overall weight becomes excessive. Furthermore, in the case of the pultrusion method, the pulling force becomes exceedingly large, and in practice fabrication becomes impossible.

[0005] It is also possible to use the method of winding a prepreg onto a core, but since it is necessary to heat the prepreg in an oven to bring about curing, there are still limitations in terms of the diameter and length of the body which can be molded, and the fabrication of large-diameter long FRP tubular bodies using this method is difficult. Furthermore, since a stage for fashioning or preparing the prepreg itself, a stage for the winding thereof and a stage for heating and curing are all required, production costs are increased. Moreover, since prepregs generally possess sticky characteristics (tackiness), handling is poor.

SUMMARY OF THE INVENTION

[0006] This invention relates to the construction of large diameter and long, or curved, FRP tubular bodies which can be easily and cheaply produced, and a method for the production thereof.

[0007] The invention relates to a method for the production of an FRP tubular body in which a resin distribution medium (which may jointly comprise a core material or the inner core) and a reinforcing fiber substrate are arranged at the outer periphery or inner periphery of a tubular or solid core and, after covering at least said resin distribution medium and reinforcing fiber substrate with an airtight material, the interior is placed under vacuum, and along with injection of the resin and distribution thereof in the resin distribution medium surface direction, impregnation of the reinforcing fiber substrate is effected. By using the FRP tubular body production method of this invention, it is possible to produce still larger size FRP tubular bodies by using a core which is divided into two or more parts in its circumferential direction, and the FRP tubular body thus obtained that is divided into two or more parts in its circumferential direction is integrally coupled. In addition, integral molding is also possible in a state in which straight and curved portions are continuously connected, by employing a hollow tube as the core, around which the resin distribution medium and reinforcing fiber substrate are arranged, and using a mold with a curved cavity as the airtight material the interior is placed under vacuum and the hollow tube caused to expand, after which resin is injected and caused to impregnate the reinforcing fiber via a resin distribution medium.

[0008] Again, the invention relates to an FRP tubular body in which an FRP layer and a resin distribution medium are concentrically integrally coupled. The tubular body of the invention can have a construction possessing straight and curved portions, or it can

have a construction divided into two or more components in the circumferential direction with the divided components being integrally coupled together. Furthermore, a tubular core can be utilized as it is, and by using a resin distribution medium having grooves at the surfaces and arranging reinforcing fiber substrates at both the inner and outer faces of the resin distribution medium, it is possible to produce large size tubular bodies with a sandwich structure.

[0009] The method of producing the FRP tubular body of this invention comprises a method in which a resin distribution medium is arranged at the outer periphery of a core, and around this is arranged a fiber reinforcing substrate and after covering the whole with an airtight material (such as a vacuum bag), the interior covered by the airtight material is placed under vacuum, and along with injection of the resin and distribution thereof in the resin distribution medium surface direction, there is impregnation of the aforesaid reinforcing fiber substrate.

[0010] In an FRP tubular body as described above, the FRP layer can be a sandwich structure with FRP layers arranged at both the inner and outer faces of a tubular core material. In such circumstances, it is preferred that the core material has grooves for resin distribution and serves both as a core material and as a resin distribution medium. In order to reduce the weight, the core material is preferably a foam.

[0011] Specifically, one example of the method of producing an FRP tubular body of this invention is a method in which, around the outer periphery of a core, there are arranged in turn a first reinforcing fiber substrate, a combined core material/resin distribution medium of tubular shape which has grooves for resin distribution, and a second reinforcing fiber substrate, and, after covering the whole with an airtight material, the interior covered by the airtight material is placed under vacuum, a resin is then injected into a groove in the resin distribution medium and, along with distribution of the resin in the resin distribution medium surface direction, impregnation of the first and second reinforcing fiber substrates is effected. In this method, by further interposing a resin distribution medium between the outer periphery of the core and the first reinforcing fiber substrate, along with distribution of the injected resin in the resin distribution medium surface direction it is possible to bring about more reliable impregnation of the first reinforcing fiber substrate.

[0012] Still more specifically, in the aforesaid two production methods, the core of the body which is being molded and the reinforcing fiber substrate, etc., are disposed horizontally and, at one or two locations at the uppermost portion of the tubular body arrangement, there are provided vacuum suction lines extending in the lengthwise direction. Moreover, resin injection lines are provided at one or two locations at the lowermost portion, and where there are two such locations, the injection of the resin may be commenced simultaneously. If a time difference arises, a leftwards/rightwards imbalance occurs in the resin flowing in the circumferential direction and the flow of the slower resin may be impaired.

[0013] Again, depending on the circumstances (in particular in the case of a diameter of several meters), a vacuum suction line may also be provided at an intermediate location other than at the uppermost portion, and when the resin injected from the lowermost portion reaches this vacuum suction line, further resin may then also be injected from this vacuum suction line (because the fluidity is better, the resin resistance is lower in the resin flow direction from the injection position).

[0014] Where a tubular core is employed, this may be left as part of the FRP tubular body, but where it is necessary that the tubular core be removed after FRP molding due to, for example, a requirement to reduce weight further, a release material such as a nylon woven fabric (optionally the surface is Teflon-coated, for example) is interposed between the core and the reinforcing fiber substrate, in particular the first reinforcing fiber substrate, prior to the molding, so that it is then possible following the molding to remove the tubular inner core along with the release material. In the case where the tubular core is left behind, the tubular core itself acts as a support, so that no separate large molding means is necessary and, furthermore, restrictions in terms of length and diameter are essentially eliminated. Consequently, long items and those of large diameter with an external diameter of 1 m or more can readily be produced.

[0015] Furthermore, it is possible for the remaining tubular core and resin distribution medium to take some of the burden from the FRP layer in terms of the loads of different mechanical characteristics, such as the bending and torsional stresses which act thereon, and in the case where a gas or fluid for example is sealed in the interior of the tubular body, not only is it possible to maintain greater gas-tightness but even if the FRP layer sustains damage or cracks, leakage of the gas or liquid can be prevented.

[0016] In the case where metal is used as the tubular core, in addition to advantages of the kind described above, and the tubular body is subsequently to be connected to some separate member, by precision machining of the metal core beforehand such connection can be made highly accurate. Again, in the case where the tubular inner core is an engineering plastic or a prior-molded FRP, it is possible to produce a reinforced FRP tubular body while still maintaining light weight.

[0017] On the other hand, the FRP tubular body of this invention can be produced as an integrally-formed FRP curved support having a support portion and an arm portion which curves and extends from the support portion, and in such circumstances the angle of the curving and extending arm portion in terms of the support portion preferably lies in the range of 5 to 120°. The FRP curved support of this invention is especially suitable for long items where the combined length of the support portion and the arm portion is at least 3 m.

[0018] This FRP curved support may include only the support portion and the arm portion but, by providing a flange member at the end face of the support portion away from the arm, the FRP curved support can be readily secured to a base or other such fitting. The flange member can be constructed separately from the supporting portion and connected to the supporting portion by means of adhesion or fastening, or a flange can also be integrally formed with the support portion. Vacuum molding may also be carried out in accordance with this invention with a reinforcing fiber substrate again being arranged around the joint.

[0019] In the method of producing an FRP curved support of this invention, the support portion and the arm portion can be integrally molded by arranging reinforcing fiber substrate around a combined core/resin distribution medium at the surface of which resin flow channels have been formed, then placing these in a mold with a curved cavity to serve as the airtight material and applying a vacuum to the interior, after which resin is injected so that along with distribution of the resin at the surface of the reinforcing fiber substrate, impregnation of the reinforcing fiber substrate is effected.

[0020] Again, the support portion and the arm portion can be integrally molded by arranging a resin distribution medium around a hollow tube as the core and arranging reinforcing fiber on top, after which these are introduced into a mold with a curved cavity and the interior placed under vacuum, and along with injection of resin and distribution thereof at the surface of the reinforcing fiber substrate, impregnation of the reinforcing

fiber substrate is effected, and, furthermore, pressure may be applied within the hollow tube.

[0021] In the FRP curved support of this invention as described above, it is possible for both the support portion and the arm portion to be made of FRP, so that when compared to conventional such metal-made items it is possible to markedly reduce the weight and, furthermore, the handling properties are outstanding. Being light in weight, no heavy machinery is required at the time of employment and the strength required of the base or the like is also reduced.

[0022] Moreover, since the structures of this invention are made of FRP, there are substantially no problems of rusting. Furthermore, since molding is easy, it is also possible to carry out on-site molding at the location where the support is to be positioned, and reduction in costs is achieved due to the lowering of transportation expenses.

[0023] In addition, since it is possible to achieve a considerable weight reduction not just in the case of the support portion but also in the case of the arm portion which curves and extends therefrom, deflection of the member under its own weight is kept to a low level compared to the case of a metal-made item, and so it is possible to increase the length of the arm portion. Furthermore, an FRP curved support is outstanding in its impact absorption capacity compared to a metal-made item, so that even in the case of motor vehicle impact, or the like, motor vehicle damage may be kept low and it is also possible to suppress the adverse effects on the vehicle passengers.

[0024] Thus, an FRP curved support with outstanding characteristics not found hitherto is easily, reliably and cheaply produced by the aforesaid production methods of this invention.

[0025] Moreover, in this invention, it is also possible to produce FRP tubular bodies of large size by the integral coupling of divided members, based on division into two or more in the circumferential direction, obtained using a core which has been divided into two or more parts in the circumferential direction.

[0026] Various modes can be adopted for connecting these divided components. For example, a construction is possible where stepped portions are formed at the opposing end faces of adjacent divided components and, by inserting connecting members between the opposing end faces, and fitting together the connecting members and stepped portions, the divided components are thereby joined together.

[0027] Again, there can be employed a construction in which recesses are formed at the opposing end faces of adjacent divided components and, by fitting a connecting member into these recesses, the opposing end faces are thereby butt-joined.

[0028] Furthermore, there can be employed a construction in which mutually-engaging projecting/recessed parts are formed at the opposing end faces of adjacent divided components, so that the end faces may be directly coupled together.

[0029] The divided components can themselves have an FRP single sheet structure but, in order to raise the strength and rigidity while at the same time maintaining the lightness of the whole body, it is preferred that these divided components have a sandwich structure in which FRP skin layers are provided at both faces of a core material (which also serves as the resin distribution medium).

[0030] The tubular portion of the FRP tubular body is not restricted to a circular tube and it may also have a conical form or be a cylinder of triangular, quadrangular or polygonal cross-section. In the case where it has a tubular portion of circular or elliptical cross-section, the divided components of the tubular body may be constructed from circular arc-shaped members, while in the case where it has a tubular portion of triangular, quadrangular or polygonal cross-section, the divided components may be composed of flat shaped or bent panel members where flat sheets are combined in an L-shape or U-shape.

[0031] Where divided components are to be integrally coupled, the number of such divided components may be two or more than two, with the number of divisions being decided in accordance with the outer diameter of the finally-formed tubular portion. Preferably, the greater the outer diameter the greater the number of divisions, so that in this way the individual divided components are kept small and their molding is facilitated.

[0032] Thus, in the case of construction from components based on the division of the tubular portion of the tubular body in two or more parts in the circumferential direction, even in the case of large tubular portion where the outer diameter is 3 m or more, the size of the individual divided components is small. Consequently, by division into a suitable number of parts, each divided component is a small part relatively close to being flat, so that molding, and the arrangement and laying-up of the reinforcing fiber at the time of molding, are considerably facilitated. Again, there is no need to use a large mold and it is possible thereby to further reduce production costs.

[0033] Moreover, since the divided components can be integrally coupled via connecting members or by fitting together their end faces, on-site connection and assembly are possible. Thus, when transporting to a site, the divided components are of small size and transportation is easy and cheap.

[0034] Again, by increasing the number of divisions, it becomes possible to produce large FRP tubular bodies of outer diameters of 10 m and above, the reliable production of which has not been possible hitherto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] Figure 1 is a partial perspective view of an FRP tubular body relating of an embodiment of the invention.

[0036] Figure 2 is a perspective view showing a method of producing the FRP tubular body of Figure 1.

[0037] Figure 3 is a perspective view of a tubular core illustrating another method of producing the FRP tubular body.

[0038] Figure 4 is a partial perspective view of an FRP tubular body of another embodiment of the invention.

[0039] Figure 5 is a perspective view of the core material of the FRP tubular body in Figure 4.

[0040] Figure 6 is a perspective view showing a method of producing the FRP tubular body of Figure 4.

[0041] Figure 7 is a side view of an FRP curved support according to an embodiment of the invention.

[0042] Figure 8 is an enlarged sectional view of the flange member in the case where the support in Figure 7 has a flange member.

[0043] Figure 9 is a partial sectional view of a support showing an example where the flange is integrally molded.

[0044] Figure 10 is a transverse sectional view of an FRP tubular body OF another embodiment of the invention.

[0045] Figure 11 is a partial sectional view showing another joint structure for the divided components.

[0046] Figure 12 is a partial sectional view showing yet another joint structure for the divided components.

[0047] Figure 13 is a partial sectional view showing an example of the case where a sandwich structure is adopted for the divided components.

[0048] Figure 14 is an outline perspective view showing another example of the shape of the tubular portion.

[0049] Figure 15 is an outline perspective view showing yet another example of the shape of the tubular portion.

[0050] Figure 16 is an outline perspective view showing yet another example of the shape of the tubular portion.

[0051] Figure 17 is an outline perspective view showing yet another example of the shape of the tubular portion.

[0052] Figure 18 is an outline perspective view showing yet another example of the shape of the tubular portion.

DETAILED DESCRIPTION OF THE INVENTION

[0053] Preferred practical embodiments of this invention are explained below with reference to the drawings.

[0054] Figure 1 shows an FRP tubular body of an embodiment of this invention. In this embodiment, the FRP tubular body 1 comprises tubular core 2, an FRP layer 3 arranged around the outer periphery thereof, and a resin distribution medium 4 interposed between the tubular core 2 and FRP layer 3, with tubular core 2 and FRP layer 3 being integrally coupled by means of resin.

[0055] The tubular core 2 may either comprise a resin or an FRP. Resin distribution medium 4 comprises, for example, a reticulate material, and it is possible as well to effect resin distribution in the surface direction at the time of molding, and impregnation of the reinforcing fiber substrate can be carried out.

[0056] Consequently, such an FRP tubular body 1 may be produced for example as shown in Figure 2. In this method a resin distribution medium 4 is arranged at the outer periphery of tubular core 2, and around this is arranged the reinforcing fiber substrate 5 and then, after covering the whole with an airtight material 6 (for example, a vacuum bag), suction is applied to the interior covered by airtight material 6 to produce a vacuum state (a reduced pressure state), and, along with injection of the resin and distribution thereof in the resin distribution medium 4 surface direction, there is also impregnation of reinforcing fiber substrate 5. Following the impregnation, the resin is cured and FRP layer 3 and

tubular core 2 are integrally coupled. The tubular core 2 is left as an integral part of FRP tubular body 1.

[0057] Instead of the resin distribution medium 4 comprising a reticulate material, it is possible to form grooves for resin distribution in the outer periphery of the tubular core 2 so that the grooves provide the function of a resin distribution medium. For example, as shown in Figure 3, large grooves 12 that extend in the lengthwise direction and small grooves 13 which extend in the circumferential direction are cut into the outer periphery of tubular core 11, so that the tubular core serves both as a tubular core and as a resin distribution medium. Resin is injected from an end of a large groove 12 so that, while distribution of the resin is brought about, the impregnation of reinforcing fiber substrate can be effected.

[0058] Moreover, in this invention, it is possible to construct the FRP-containing layer of the FRP tubular body in the form of a sandwich structure. For example, as shown in Figure 4, FRP-containing layer 22, which is arranged around tubular core 21, has a sandwich structure with FRP layers 24a, 24b provided at both the inner and outer faces of a tubular core material 23, and a structure can be produced with this FRP layer 22 integrally coupled to tubular core 21 by means of resin. Between FRP layer 22 and tubular core 21, there may be interposed a resin distribution medium as described above, or grooves for resin distribution may be cut in the outer face of tubular core 21 so that it serves both as a tubular core and as a resin distribution medium.

[0059] It is preferred, as shown in Figure 5 for example, that grooves for resin distribution be cut in core material 23, and so this serves as both a core material and a resin distribution medium. In the example illustrated in Figure 5, large grooves 25 running in the lengthwise direction and small grooves 26 running in the circumferential direction are cut in the outer face of core material 23, and impregnation of the reinforcing fiber substrate is effected while injecting and distributing resin from an end of a large groove 25. In the case of the production of a sandwich structure as shown in Figure 4, it is preferred that such grooves 25, 25 are also provided at the inner face of core material 23. In order to facilitate formation of the core material in which grooves are cut, said core material may be divided in its circumferential direction.

[0060] A large groove 25 should be provided in at least one location around the circumference and, preferably, another one is located on the opposite side, with the number

being increased as the diameter is increased. The large groove 25 provided at the bottommost position is used as a resin injection line, while large grooves provided elsewhere may also be jointly used, depending on the circumstances, as vacuum suction lines.

[0061] This kind of FRP tubular body 27 with an FRP layer 22 having a sandwich structure can also be produced by the same method as above. For example, as shown in Figure 6, there are provided, in turn, around the outer periphery of tubular core 21, a first reinforcing fiber substrate 28a, a combined tubular core material/resin distribution medium 23 having grooves for resin distribution in its inner and outer faces, and a second reinforcing fiber substrate 28b, and then, after covering the whole with airtight material 29, the interior region covered by airtight material 29 is placed under vacuum, and while resin is injected and distributed from the end of a large groove 25, impregnation of the reinforcing fiber substrates 28a, 28b is effected. Following impregnation, the resin is cured and the FRP layer 22 and tubular core 21 are integrally coupled.

[0062] Furthermore, as shown in Figures 1, 2, 4 and 6, by interposing a release material comprising a woven fabric (not illustrated) between the tubular core and (first) reinforcing substrate, so as to make separation of these possible, following the FRP molding the tubular core can be withdrawn from the FRP tubular molded body. As a result, a further reduction in weight can be achieved compared to the case where the tubular core is integrally coupled to the FRP tubular body as described above.

[0063] Figure 7 shows an FRP curved support 31 of an embodiment of this invention. FRP curved support 31 has a support portion 32 and an arm portion 33 which curves from the upper end of said support portion 32 and extends at an angle. This support portion 32 and arm portion 33 are integrally molded.

[0064] The structure of the FRP curved support 31 of this invention is complete as it is but, in practice, it is most often employed fitted to a base or the like and so, as shown by the two sets of dotted lines in Figure 7, at the end of support portion 32 on the other side from the arm portion, that is to say at the bottom end of support portion 32 in this embodiment, it is preferred that there be provided a flange member 34 used for fitting and securing to a base or the like.

[0065] With regard to this flange member 34, as shown in Figure 8 for example, said flange member 34 can be separately formed from the support portion 32 and this

flange member 34 then joined to support portion 32 by adhesion or fastening. In the case of a separately formed flange member 34, there may be used for example a separately molded FRP product or a durable metal such as stainless steel, and depending on the circumstances there can also be formed a hybrid structure of FRP and metal.

[0066] Again, the flange member can also be integrally molded with the support portion 32. For example, as shown in Figure 9, a flange 34a comprising FRP can be integrally molded with the support portion 32 at the bottom end of said support portion 32. In such circumstances, joining together by adhesion or fastening is unnecessary and, furthermore, being an FRP molded body connected to support portion 32, it is possible to ensure sufficient strength and rigidity in flange portion 34a.

[0067] Even where the length of such an FRP curved support 31 is 3 m or above, production can be carried out easily and cheaply by the production method described below. FRP curved support 31 is extremely light compared to a conventional support made of metal, and even at a length of 3 m or above it has outstanding handling characteristics, so large-size heavy machinery or the like is not required at the time of employment. Furthermore, since the support as a whole is considerably reduced in weight, the load on the base or the like is also reduced, so the strength required of the base or the like is also lowered.

[0068] With regard to the support itself too, sufficiently high strength and rigidity can be ensured by suitable choice of the type of reinforcing fiber, the percentage impregnation and the type of resin, etc., in accordance with the usage objectives. Furthermore, being light, there is very little deflection of the support under its own weight, and it is possible to produce long supports easily. Moreover, since the support is made of FRP, there is fundamentally no problem of rusting. In addition, when compared to a metal-made item, the impact absorption capacity is excellent and it behaves advantageously in terms of motor vehicle impact and the like.

[0069] An FRP curved support 31 with these outstanding characteristics can typically be produced easily and cheaply by either of the two methods of production of this invention described above. The flange member may be separately molded and then connected to the support portion of the molded FRP curved support, or the shape of the mold may be designed to include a flange member, which is integrally molded with the aforesaid support portion. An FRP curved support of specified shape can readily be

integrally molded by either of the aforesaid methods and, even when of long length, production can be carried out simply and cheaply.

[0070] The applications of the FRP curved support of this invention are not particularly restricted, but, to provide some examples, it is suitable as a garage support, a support for signboards such as advertisements and road signs, a support to hold up a roof such as in the case of a petrol station/gasoline stand, or as a support for a veranda or for a canopy.

[0071] Figure 10 shows a cross-section of the tubular portion of an FRP tubular body 41 of another embodiment of this invention. Tubular portion 42 of this FRP tubular body 41 has an external diameter of at least 3 m, and it is constructed as a connected body of components 43 based on division into two or more parts (in the example in the figure there are four) in the circumferential direction. Each divided component 43 is molded as a circular-arc shaped component, and such mutually adjacent divided components 43 are integrally coupled via connecting members 44 interposed between them.

[0072] The opposing end faces of the adjacent divided components 43 are molded with stepped regions 45 of projecting/recessed shape, and both end faces of the connecting members 44 are also molded with stepped regions 46 of projecting/recessed shape, so that the stepped region 45 on the divided component 43 side and the stepped region on the connecting member 44 side mutually fit together. After fitting the connecting members 44, they are secured by adhesion or the like, so that there is integral connection between divided component 43, connecting member 44 and divided component 43 continuously in the circumferential direction.

[0073] Connecting members 44 are separately molded from the divided components 43 and, while they may be composed of metal or other such material, in order to maintain the lightness of the tubular body as a whole, and again in order to ensure good connection with the divided components 43, it is preferred that they comprise the same FRP as said divided components 43.

[0074] Constructions other than as described above can also be utilized for the integral coupling of the divided components. For example, as shown in Figure 11 recesses 55 can be formed at the opposing end faces 54 of mutually adjacent divided components 53, then a flat connecting member 50 fitted in each recess 55 and connection effected with opposing end faces 54 butting.

[0075] Again, as shown in Figure 12, the opposing faces 64 of mutually adjacent divided components 63 may be given projecting/recessed forms which mutually fit together, and construction effected by directly joining together the end faces 64 without an interposed connecting member.

[0076] Moreover, while the divided components themselves can be given a single sheet structure of FRP, a sandwich structure with a core material arranged between FRP skin sheets is more preferred in terms of satisfying all the requirements of lightness, strength and rigidity.

[0077] For example, as shown in Figure 13, a divided component 73 is preferred which has a sandwich structure in which FRP skin sheets 72a and 72b are arranged at the two faces of a core material 71. In such a sandwich structure, where required, it is possible to provide ribs 74 at suitable positions at a suitable spacing. By means of ribs 74, as well as it being possible to further enhance the strength and rigidity, the shape retension is also improved. The material for ribs 74 may be wood or metal but, taking into account integral moldability to FRP skin sheets 72a and 72b, it is again preferred that they comprise FRP. As the material for core material 71 there can be used wood or a foam, but from the point of view of lightness a foam of low specific gravity is preferred. In particular, by using such a core material 71 it is possible to enhance the thermal insulation properties.

[0078] With regard to the shape of the tubular portion of the FRP tubular body of this invention, providing it constitutes a tubular body, any shape thereof can be employed. As well as the circular tubular shape of the kind shown in Figure 10, there can be employed structures such as the circular conical frustum-shaped tubular portion 81 shown in Figure 14, the circular conical frustum-shaped tubular portion 82 where the generatrix curves as shown in Figure 15, the tubular portion 83 of quadrangular cross-section shown in Figure 16, the tubular portion 84 of hexagonal cross-section shown in Figure 17 and the tubular portion 85 of octagonal cross-section shown in Figure 18.

[0079] Furthermore, the shape of each divided component can also be freely changed in accordance with the particular shape of the tubular portion as described above. In contrast to the divided components 43 shown in Figure 10 which comprise circular arc-shaped members of substantially fixed cross-sectional shape, in the case for example of the tubular portions 81 and 82 shown in Figure 14 and Figure 15, the divided members thereof, while still circular-arc shaped, will vary continuously in their cross-sectional shapes.

Again, in the case of tubular portions 83, 84 and 85 shown in Figures 16 to 18, each divided component can be formed as a single flat-sheet shape or can be formed as an L-shaped or U-shaped panel member.

[0080] In this way, in the case where the components from which the tubular portion is constructed comprise a plurality of members by division in the circumferential direction, each divided component can be made small and molding is simple, so it is possible in practice to produce a large-size FRP tubular body 41 of external diameter 3 m or more, easily and cheaply.

[0081] Furthermore, by employing a joint structure between divided components as shown in Figures 10 to 12, connection and assembly on site becomes possible.

[0082] Moreover, even where the tubular body as a whole is large, since each divided component can be molded to a small size, there are essentially no restrictions in terms of molding on the shapes of the divided components themselves, and it becomes possible to freely and easily produce tubular bodies of various shapes as shown in Figures 14 to 18, and a broadening of applications can be achieved.

[0083] As the reinforcing fiber of the FRP layer in the aforesaid FRP tubular bodies, it is preferred that there be used carbon fiber unidirectional material, woven material, mat or strands, or glass fiber unidirectional material, woven material, mat or roving, either on their own or in the form of mixtures. In particular, in order to achieve maximum weight reduction, the use of carbon fiber is preferred. Furthermore, with regard to the carbon fiber, rather than using carbon fiber yarn that normally contains less than 10,000 filaments, the use of a carbon fiber filament tow where the number of filaments lies in the range 10,000 to 300,000, and preferably 50,000 to 150,000, provides better results in terms of resin impregnation, handling of the reinforcing fiber substrate and cost of the reinforcing fiber substrate, so this is preferred. Again, where a carbon fiber woven material is arranged at the surface of the FRP tubular body, there is enhanced surface design potential, so this is further preferred. Again, where required, or in accordance with the mechanical properties demanded, the reinforcing fiber substrate may be formed by superimposing a number of reinforcing fiber layers, and this reinforcing fiber substrate employed for resin impregnation. As the superimposed reinforcing fiber layers, there can be suitably superimposed layers of unidirectionally arranged carbon fiber or woven

material layers, and the fiber orientation direction can be appropriately selected in accordance with the required strength direction.

[0084] It is preferred, in terms of the molding characteristics and cost, that the FRP resin be a thermosetting resin such as an epoxy, unsaturated polyester, phenolic or vinyl ester resin. However, it is also possible to use thermoplastic resins such as nylon and ABS resin, or mixtures of thermosetting resin and thermoplastic resin.

[0085] As the core material, there can be used foam, wood or the like, but from the point of view of weight reduction a foam is preferred. As the foam material, there may be used polyurethane, polystyrene, polyethylene, polypropylene, polyimide, PVC, silicone or the like, and it is preferred that the specific gravity of the foam be within the range of 0.02 to 0.2. The type and specific gravity of the core material can be selected according to the properties demanded of the FRP tubular body and the type of resin used, etc. If the specific gravity is less than 0.02, there is a fear that sufficient strength will not be obtained. On the other hand, if the specific gravity exceeds 0.2 then, while the strength is raised, the weight is also increased and this goes against the objective of weight reduction.

[0086] Examples of applications of the FRP tubular body of this invention include large-size tanks, waste gas ducts (chimneys, ducts for discharged gases within high-speed road tunnels, and the like), cooling tower containers, silos, water channel shutters, broadcasting masts, towers, revolving tubes in parks, and lamp posts, etc.

[0087] As explained above, in accordance with the FRP tubular body of this invention and method of manufacture thereof, there are no substantial restrictions on the length and diameter of the tubular bodies, and long large-diameter FRP tubular bodies can be molded easily and cheaply. Again, since no special molding equipment is required, from this aspect too it is possible to produce the desired FRP tubular bodies easily and cheaply.

[0088] In addition, the FRP curved support of this invention is light and easy to handle, does not require large heavy machinery or the like at the time of employment, permits the strength of the base to be lowered, and essentially shows no problem of rust generation. Furthermore, there is little deflection under its own weight and the length of the arm portion can readily be increased. Moreover, it can show an outstanding impact absorbing capacity in terms of motor vehicle impact and the like. Thus, it is possible to

obtain a support with extremely outstanding properties not found with conventional metal-made items.

[0089] In addition, where the tubular portion is composed of a plurality of components by division in the circumferential direction, the molding of each such divided component is easy and it becomes possible to produce large-size FRP tubular bodies of size 3 m and above, and even 10 m or above, both easily and cheaply. Again, large size molds are unnecessary and, from this aspect too, production can be simplified and production costs lowered. Furthermore, by employing a joint construction for the divided components as shown in Figures 10 to 12, it becomes possible to carry out connection and assembly easily on site. Moreover, since each divided component is small, transportation is both cheap and easy.